NAVSEA WARFARE CENTERS INDIAN HEAD

Connections

Research

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Inside the Box:

Turning on the Future Warfighter's Technology Awareness

The usual assumption is that today's young people are technology-savvy. They grew up with computers and are comfortable working and communicating electronically. But according to William C. Miller, Academic Dean and Provost at the U.S. Naval Academy, comfort with technology is not the same thing as awareness of how it works and how its capabilities can be harnessed to solve practical problems — especially problems facing the warfighter.

"Fewer midshipmen are coming to the Academy these days having spent time with their heads under the hood of a car," says Miller. "They know how to go down to the electronics store, buy a computer, plug it in, and use it, but not too many of them know what's inside the box. As officers in the future Navy and Marine Corps, they will need more than push-button familiarity with technology."

Miller believes that one of USNA's roles in preparing midshipmen for future leadership positions is to get them beyond their comfort zone, to push them deeper toward an understanding of the technologies they will use as tools on the battlefield. Technology awareness will be required not only of science, engineering, and information technology majors, but English, economics, and political science majors too.

"The Navy has always relied on technology to retain superiority, and likewise, technology has traditionally been ➤

Midshipman works in biometrics lab at the Academy.

Inside

embedded in the Naval Academy's educational programs," says Professor Reza Malek-Madani, Director of Research and Scholarship at USNA. "What has changed is the urgency of finding solutions to contemporary problems of national security. In that regard, the technology awareness of our midshipmen has become a more urgent priority in the classroom and laboratory."

Know Your Technology

Today's Fleet operates with fewer ships and aircraft, but the operational demands are no less, notes Miller. During the cold war, the United States faced a monolithic enemy, and the threats were largely known. In contrast, says Miller, "Today's warfighter must respond to messy and unstructured challenges, which requires thinking and decision-making on the battlefield."

To respond to global threats and achieve the time-critical targeting necessitated by new types of conflict, the warfighter must have an informed understanding of the capabilities and limitations of technology, says Miller. For example, technology awareness would help an officer make intelligent decisions about using equipment that has become degraded because of operational use or damage.

Awareness of how technology works can also help an officer think more creatively on the battlefield. For example, in stressful situations it might be possible to use technology tools in ways not envisioned by the manufacturer or inventor. "To employ the technologies in novel or unanticipated ways requires a higher level of understanding than just turning a knob," says Miller.

Another important attribute of a Navy or Marine Corps officer is the ability to effectively communicate with personnel who maintain and repair the high-tech equipment used in modern warfare. Leaders who can converse about the condition of an item and the options and timelines for repair earn the respect of highly skilled maintenance personnel. For this reason too, an officer with technology know-how is able to lead more effectively, says Miller.

Under the Hood

For all the reasons just noted, Naval Academy curricula are structured to recognize the need for officers to have a thorough grounding in mathematics, science, and engineering. Regardless of their major, all midshipmen must take four semesters of math, including calculus, two semesters of physics, two semesters of chemistry, and five semesters of engineering.

The Naval Academy offers 19 majors. Although many midshipmen major in non-science fields, all of them graduate with a bachelor's degree in science because of the emphasis on technical courses. All midshipmen acquire considerable S&T experience while earning their degrees. "We are an engineering school at heart," Dean Miller says.

Many of the students who are attracted to military careers are "kinesthetic learners," according to Miller. They absorb more when hands-on opportunities are provided. The USNA curricula stress this type of learning, which is especially effective when teaching complex concepts. For example, every electrical engineering course incorporates a lab where devices are built and concepts are demonstrated in such areas as lasers or digital signal processing.

"All the midshipmen spend a significant amount of time in labs, as compared with their peers at other colleges or universities," notes Dr. Delores Etter, professor of electrical engineering and the first occupant of the Naval Academy's Office of Naval Research Distinguished Chair in Science and Technology.

Within the engineering curricula, "getting under the hood" involves building things. Midshipmen third-class (sophomores) build airplanes to learn about aircraft lift characteristics and flight dynamics. As they move deeper into their studies, they build more sophisticated machines. Many of these vehicles or devices are more than simple classroom models. According to Miller, "When the space shuttle returns to flight and heads to the international space station, it will be transporting a satellite designed and built by midshipmen as part of an advanced aerospace engineering course."

Kinesthetic learning activities often depend on leveraging the USNA's natural affinities with the

Navy Warfare Centers. "The enthusiasm that marks working scientists and engineers is contagious," says Miller. "Exposing the midshipmen to the people in the Warfare Centers gets them excited about the process of discovery and shows them how real scientists and engineers engage in problem-solving."

The Long View

The emphasis on technology in the USNA curricula parallels the federal government's emphasis on supporting science and technology as a long-term national priority. "The next generation of Navy and Marine Corps officers will need to be familiar with technology and must understand why long-term investments in S&T are critical to the military's future," says Etter.

Etter is keenly qualified to address S&T issues within the context of the Naval Academy's educational mission. Before coming to the Naval Academy, she served as Deputy Under Secretary of Defense for Science and Technology. Among many other S&T credentials, Etter is also a presidential appointee to the National Science Board and served in teaching and administrative positions at the University of Colorado.

In the classroom and laboratory, Etter is able to get the message across to her students that "S&T is not something you order up and it's done; it requires a long-term investment in people and facilities." As the midshipmen pursue their future careers, they will not only employ the technologies being developed now, many of them will influence funding decisions that will determine the continued superiority of the U.S. Fleet, Etter notes.

Fostering Relationships with Warfare Centers

To enhance "under the hood" learning opportunities, USNA is partnering with the Navy Warfare Centers to provide opportunities for exposing the midshipmen to ongoing research. The summer internships at the Naval Surface Warfare Center, Indian Head Division, are one example (see page 4) of the ongoing effort to integrate research and education at the Naval Academy. In addition, scientists and engineers at Indian Head present visiting lectures to the midshipmen, and are available for consultation with USNA faculty on student research projects.

"From the standpoint of our national defense, we need technologically-savvy leaders in the Navy. Developing closer relationships

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Warfare Center S&Es to Rub Elbows with the Future Navy

The Office of Naval Research's N-STAR initiative will host a conference on September 20-22, 2005, that will bring scientists and engineers from the Navy Warfare Centers into the classrooms and lecture halls at the Naval Academy. There, midshipmen and faculty will be treated to lectures and demonstrations of ongoing research activities.

The conference will have an educational focus. According to Chief of Naval Research Rear Admiral Jay M. Cohen, the gathering will "provide a rich context for the traditional disciplines in which the midshipmen are being educated."

In addition, poster sessions targeted to USNA faculty and research staff will, it is hoped, spark mutually beneficial collaborations with the Navy Warfare Centers.

The conference is intended to exploit the natural connection between the research now being conducted within the Warfare Centers and the currently enrolled Brigade of Midshipmen. S&T derived from today's research will generate the tools on which those midshipmen will rely in the future as naval officers. Their awareness of the genesis of the tools will help them appreciate the critical support that S&T provides for the day-to-day operations of the Fleet.

For more information, please contact kirk.jenne@onr.navy.mil.

between the R&D centers and the Navy's institutions of higher learning is, and should be, part of our current and future strategy," asserts Bob Kavetsky, Director of the ONR's N-STAR program.

The N-STAR program (Naval Research — Science and Technology for America's Readiness) seeks to revitalize the science and technology base at the Navy's R&D centers. An important focus of the program is to groom the next generation of naval scientists and engineers by turning on young scientific and engineering talent to career opportunities at the Warfare Centers.

A Learning-Centered Institution

Under Miller's guidance as Academic Dean, the U.S. Naval Academy is "deliberately and inexorably moving toward becoming a learning-centered institution," he says. This higher education model focuses on the student's learning experience and emphasizes the application of knowledge to the "unscripted problems" of the Fleet officer's world.

This teaching model, Miller believes, is best suited to the task of fostering the technology awareness of the future warfighter and producing officers who understand how technology works and will communicate with (and support) the scientists and engineers who invent, design, and build the unsurpassed technologies employed by the Navy and Marine Corps.

Summer Internships

Naval Academy 2004 Summer Interns Impress IHDIV Mentors

Each summer, U.S. Naval Academy midshipmen are assigned to seagoing vessels or operational commands to enhance their learning and get a preview of their upcoming careers as Naval officers. Last summer, in the midst of their heavy schedules, four midshipmen volunteered for two- or three-week internship opportunities in science and engineering at the Naval Surface Warfare Center, Indian Head Division (IHDIV). It turned out to be a productive decision, both for themselves and for their mentors at Indian Head who planned and supervised their projects.

"We are impressed and honored that they used part of their summer to learn about the civilian research side of the Navy," says Research Liaison Dr. Su Peiris. "These are very bright and disciplined young people, and they are the Navy's future."

The four internships were scattered throughout the summer and depended on the midshipman's availability and the mentor's work schedule. Executive Officer CDR Robert Rochford greeted the students as they each arrived at Indian Head, introduced them to CAPT Joseph Giaquinto (himself a USNA grad), gave them a tour of the base, and showed them their accommodations at bachelor's quarters.

Peiris notes that Rochford served as a bridge for the midshipmen between the military and civilian worlds. "This is a unique environment for military personnel. I wanted to be sure they felt comfortable, and then I let them go out and do their thing," says Rochford.

That "thing" was to dive right into their work. Although it is difficult to devise a project that can be completed within a compressed time frame, the volunteer mentors at IHDIV identified areas of research well suited to the skills and talents of the students. Just as important, the projects yielded meaningful results that contributed to the design or research objectives of the laboratory that sponsored the interns.

"We had actually been looking for an undergraduate or a beginning graduate student with reasonable math competence and some understanding of engineering who could write some software to enhance one of our warhead design programs," recalls Indian Head's Art Boyars. "I could not justify the time it would

take for one of us to do it. So when MIDN Shaunnah Wark came aboard with the right background and programming skills, it was a perfect fit."

In addition to generating a useful work product, the internships provide an opportunity for future Naval officers to understand what goes on at Indian Head in support of the warfighter, notes Dr. Doug Bohl. "The interns not only learn about the labs they work in, they also tour the other facilities we have here and see a side of the Navy they might not otherwise know about. It will pay dividends, both for us and for them, in the future," says Bohl.

The mentors, interns, and projects for summer 2004 are described briefly in Exhibit 1.

A Lasting Impression

"The midshipmen who interned last summer were consummate professionals," says Rochford. "Each one was extremely dedicated and accommodating to whatever was asked of them." Peiris agrees, describing them as extremely focused on working hard and making a real contribution.

"I was impressed that Jeremie was able to complete the predictive model in such a short time frame," says Lopatin. Likewise, Bill Koppes praised the work done by Andrew Townsend, saying "Bright chemistry majors like Andrew will always be welcome in our laboratory."

The students were equally enthusiastic about the opportunity they had to work with the eminent scientists and engineers who provide technical solutions for the warfighter. "One of the most notable characteristics I found at Indian Head was that everyone loves the job they are doing," says MIDN Wark. "This was very beneficial to me in terms of job productivity and providing me with an atmosphere in which I could learn."

MIDN Isaiah Gammache agrees, citing his newfound understanding of the role of the Warfare Centers as one of the benefits of his internship.

"The midshipmen's exposure to the many brilliant minds at Indian Head will leave them with a lasting

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Exhibit 1
Summer 2004 Intern Projects

- *Doug Bohl, IHDIV, hosted MIDN 2/C Isaiah Gammache (Physics, class of 2006)*

  Project: Laser-based Flow Diagnostics. Developed an experimental model of the fluid dynamics of energetic materials during the mixing process.

- *Bill Koppes, IHDIV, hosted MIDN 2/C Andrew Townsend (Chemistry, class of 2006)*

  Project: Hypergolic Fluid for Mine Countermeasures. Conducted experiments to survey conditions for a study of the kinetics of a chemical reaction related to the ignition of the explosive TNT.

- *Art Boyars, IHDIV, hosted MIDN 1/C Shaunnah Wark (Systems Engineering, class of 2005)*

  Project: Warhead Design Calculations. Wrote a Lethality Evaluator Surrogate computer program to support the design optimization research being conducted with the University of Maryland Department of Mechanical Engineering through the Center for Energetic Concepts Development.

- *Craig Lopatin, IHDIV, hosted MIDN 3/C Jeremie Papon (Electrical Engineering, class of 2007)*

  Project: Autonomous Health Monitoring. Developed a statistical model that combines damage modeling and sensor data to predict the lifetime of a lightbulb, justifying the next step of applying the methodology to "fuse" propellant aging models and embedded sensor data to obtain improved predictions of the service life of solid rocket motors.

impression as they go on to make their marks in the Navy," says Rochford.

Summer 2005 Opportunities

Isaiah Gammache plans to return to Doug Bohl's laboratory for a few weeks during the summer of 2005. In addition, three other midshipmen have signed up for internships at Indian Head this summer.

Midshipmen interested in the research intern program should contact Ms. Debra T. Hughes (dhughes@usna.edu; 410-293-2518). Prospective mentors interested in working with a USNA intern during the summer may contact Dr. Su Peiris, Research Liaison (suithi.peiris@navy.mil; 301-744-4252).

Research Connections is published periodically to provide information about ongoing and potential research collaborations between Indian Head and the Naval Academy.

For more information:

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Dr. Suhithi ("Su") Peiris, Research Liaison: 301-744-4252; suhithi.peiris@navy.mil

USNA:
Dr. Reza Malek-Madani, Director of Research and Scholarship: 410-293-2504; research@usna.edu

Ms. Debra T. Hughes, Research Policy Analyst: 410-293-2518; dhughes@usna.edu

Research Rebounds After Hurricane Isabel

A "heroic effort" by all hands, says Professor Reza Malek-Madani, turned what could have been a disaster for research at the Naval Academy into a temporary, though significant, setback. When Hurricane Isabel rammed the Academy's seawall one night in September 2003, the storm's seven-foot surge poured water up onto the Yard and into many of the buildings. Some parts of the 338-acre yard were completely under water.

The midshipmen were safe in Bancroft Hall, and the Academy's 108-foot patrol boats were sheltered in hurricane moorings on the upper Severn River. But the academic areas and other parts of the Yard were inundated, despite the extensive sandbag barriers that had been erected in anticipation of the storm.

Damage Assessment

The devastation of the level-five hurricane was unprecedented in the Naval Academy's history. The basements of five academic buildings were completely submerged. Half of the classrooms were rendered unusable, either because of flood damage or because the plumbing, electrical, and ventilation systems were swamped.

The ground deck of Rickover Hall, home of the laboratories of the Aerospace Engineering, the Mechanical Engineering, and the Naval Architecture and Ocean Engineering departments, sustained extensive damage. Large wind tunnels were damaged by the floodwaters, the control mechanisms of the large tow tanks were submerged, rendering the tow tanks inoperable, and the research areas for composites, materials, and engines were heavily damaged or destroyed. The impact on research by faculty and midshipmen was severe.

The Chemistry Department's

Chauvenet Hall lab deck the morning after Hurricane Isabel flooded the U.S. Naval Academy.

laboratory facilities in the basement of Chauvenet Hall, including ongoing investigations by faculty and students, were a total loss. With water coming into the ground deck laboratories to a height of four or five feet, the floodwaters "rearranged" laboratories. The incoming water removed bottles of chemicals from lab benches, gently placing the bottles on the floor as the water slowly receded. Rarely did a bottle break. The unplanned rearrangement, however, added to the time and approach required for cleanup because the floodwaters soaked off the identifying labels and markings from the chemical bottles.

"It was an event that was bigger than the power of human beings to control," says Malek-Madani, who is the Director of Research and Scholarship at the Naval Academy. "From a research perspective, the impact was huge."

"Many of the research investigations at the Naval Academy are jointly funded by the Office of Naval Research and other sources," notes Malek-Madani. Until the laboratories were repaired, no other funding could be accepted. The interruption in research, therefore, extended beyond internal faculty and student projects to sponsored efforts as well.

"It was extremely important to expeditiously repair the lab facilities and replace the equipment," says Malek-Madani. Professors were allowed to enter the buildings briefly to assess the damage and begin making plans for renovation and acquisition.

What they found initially was very discouraging. Not only were the laboratories overcome by salt water, bay sludge, and debris, but most of the lab equip-

Isabel Challenges Class of 2004 Trident Scholars

Hurricane Isabel compromised or destroyed numerous Trident Scholar research projects. With the help of other laboratories, the Trident Scholars were able to reconstitute their experiments, according to Professor Joyce Shade, Deputy Director of Research and Scholarship and coordinator of the Trident Scholar Program. Here are some examples:

MIDN Jared Patton, a Naval Architecture major, was left without a major research tool when the controls of the USNA's large tow tank were destroyed by the hurricane. Through the efforts of his project adviser, Assistant Professor Paul H. Miller, and the willingness of CAPT Steve Petri and his staff, Patton was able to make use of the David Taylor Model Basin at the Naval Surface Warfare Center, Carderock Division in Bethesda, Maryland. Patton collected data at Carderock for almost two weeks in December 2003, which allowed him to continue his Trident project despite the extensive losses to the tow tanks, support shops, model rooms, and other facilities at USNA.

MIDN Daniel Bowers, a Chemistry major, lost his entire project because the laboratory he was working in was located in the submerged ground deck of Chauvenet Hall. Through the dedicated efforts of the USNA Chemistry Department and Dr. Lee Weigt at the Smithsonian Institution Laboratory in Suitland, Maryland, and the adaptability of his project adviser, Assistant Professor Tammy L. Domanski, Bowers redesigned his project and started over in October 2003. For the reworked project, he used a small research laboratory (offered by Associate Professor Christine Copper) on the first deck of Chauvenet Hall for his chemical work, and he collaborated with Dr. Weigt for the DNA sequencing tests at the Smithsonian Laboratory.

MIDN Katherine Folz, a Chemistry major, also lost her entire project as a result of the Chauvenet Hall flooding. Following the hurricane, Folz revised the preliminary synthetic steps of the project and started over. For her chemical work, she shared the small research laboratory (offered by Associate Professor Christine Copper) with Bowers and another student. She also collaborated with staff scientists at the Naval Research Laboratory for some of the spectroscopic analyses of her reaction products.

ment was lost or damaged, including many state-of-the-art tools and devices. For example, a brand new Minilab Gas Turbine Power System, still in its delivery crate in the basement of Rickover Hall, was almost completely submerged. A new laser for the Chemistry Department (also in its packing crate) was completely under water, and the department's year-old 400-MHz Nuclear Magnetic Resonance (NMR) spectrometer was submerged and rendered inoperable.

Isabel's storm surge even muddied recognition of the research contribution made to the U.S. Fleet by the Naval Surface Warfare Center, Indian Head Division. At an entrance to Rickover Hall, the permanent display that described Indian Head's areas of research sustained extensive water damage and had to be removed.

Recover and Regroup

As in most emergencies, the goodness of people and the resilience of the Academy were in constant evidence. The 4,000-member Brigade of Midshipmen reported to clean-up duty, while a contingent of 250 public works employees and 400 contractors worked nonstop on the recovery and restoration effort.

Military police maintained security, while faculty and staff worked tirelessly to assess the damage, adjust teaching plans, and clean up and recover what could be saved. Compounding the space constraints was the fact that Michelson Hall, the other building used for math and science, was already out of commission for planned renovation.

Getting the midshipmen back to class required some creative thinking. The administration stretched the definition of "classroom" when it identified suitable spaces to resume classes, including bleachers and steps to buildings. For a short time, a 360-foot barge was made available on loan to provide temporary classroom space. All told, only one day of classes was lost because of the hurricane.

"The 2003–2004 academic year was very tough for research at the Academy, but we got generous help from our friends in the scientific community," Malek-Madani notes. For example, other laboratories pitched in to help some of the 2004 Trident scholars recover and finish their projects (see page 7).

The manufacturer of the MiniLab, Turbine Technologies, decided to remanufacture the unit rather than try to repair it. Under an expedited production and testing schedule, a new MiniLab was delivered to the Academy by mid-May 2004, even before the engineering laboratory in which it would be located was completely refurbished.

Ultimately, the costs of recovery from Hurricane Isabel exceeded $50 million, and special appropriations were necessary from the U.S. Congress to start the reconstruction and repairs. Much of that amount was devoted to repairing and rebuilding the Academy's laboratories and to acquiring new equipment. By the end of 2004, every one of the laboratories was "back onboard," says Malek-Madani.

In March 2005 one other item was replaced. A new permanent display illustrating Indian Head's research mission in support of the naval warfighter was restored to the entrance of Rickover Hall. The recovery was finally complete. Today, the Naval Academy labs show hardly a sign of the night that many midshipmen saw their first hurricane.

The new Indian Head display in Rickover Hall replaced the display ruined by the hurricane.

Spotlight on Collaborative Research

USNA Professors "Summer" at Indian Head

During the summer months, several U.S. Naval Academy professors have opted to pursue collaborative research projects with scientists and engineers at the Naval Surface Warfare Center, Indian Head Division. These summer collaborations give faculty members the opportunity to work on problems of practical interest to the Navy and Marine Corps.

Meanwhile, in exchange for a partial summer salary, Indian Head benefits from the contributions of gifted academics who have a special interest in addressing science and technology questions that advance the performance, safety, and superiority of the U.S. Fleet.

Three USNA faculty members took advantage of this collaborative program during the summer of 2004. Indian Head maintains responsibility for defining the problem and provides direction for the summer professors, who take it from there. "It's our problem and their project," explains Dr. Drew Wardlaw, Indian Head sponsor for Dr. Tom Mahar, associate professor of mathematics at the Naval Academy.

The summer research work has a direct impact on the professors' teaching, believes Mahar. "I am able to show my students that mathematics is instrumental in the day-to-day operations of the Navy," says Mahar.

Dr. Tas Liakos also values the practical nature of the collaborative research. "I usually work on more abstract problems in fluid dynamics. Through my summer research, I am able to see the physical realization of the concepts I am working on."

Equally valuable for Professor Liakos has been the opportunity to widen his network in the energetics research community. "The program put me in touch with my sponsor, Dr. Mitch Gallant in Indian Head's twin screw extrusion facility, Dr. Hugh Bruck in the Center for Energetic Concepts Development, and many other people who are at the forefront of energetics. It is a tremendous resource for me and my students."

The collaborative benefits go the other way too. "It is refreshing to work with people who bring a different perspective to the Navy's technology problems," says Wardlaw.

Following is what the summer professors did and with whom they worked. Note that many of these collaborations extend beyond the summer and turn into lasting working relationships with Indian Head researchers and with professors at the University of Maryland Department of Mechanical Engineering, IHDIV's partner in the Center for Energetic Concepts Development.

The Projects

Structural Analysis of Explosive Materials at High Pressure

Dr. Wayne H. Pearson, Associate Professor, Chemistry Department, USNA

IHDIV sponsor: Dr. Suhithi Peiris

We study explosives at high pressure to model its behavior during the high pressure and high temperature conditions present during the explosive event. X-ray diffraction from single crystals is the most descriptive method of analyzing solid-state structure. Ideal detailed structural analysis of materials at high pressure should include single crystal diffraction studies. Most studies of this nature use in-lab radiation sources. Only a few studies of single crystal diffraction using synchrotron radiation have been done.

Previously, we performed x-ray diffraction experiments of single crystals in DACs at high pressure at Cornell University's synchrotron source (CHESS). These experiments are the only single-crystal diffraction experiments done to refine structure, using synchrotron radia-

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tion, in the United States. Our samples were RDX (1, 3, 5-trinitro-hexahydro-1, 3, 5-triazine), which is a popular explosive used since World War II.

Professor Pearson obtained data at pressures of 1, 2, and 3.5 GPa. An existing data analysis package (DPS/MOSflm/CCP4, usually used by protein crystallographers) was adapted for indexing and peak integration. Structure factors were obtained at 1 GPa, and structural analysis was performed using MaXus crystallographic software. Compared to the ambient pressure structure, significant bond distortions, angular distortions, and ring puckering are evident at 1 GPa. The 2 and 3.5 GPa data indicate the existence of two separate phases, a phase change to a monoclinic structure, or a twinned crystal. It is possible that the phase change previously seen at 4.5 GPa occurs at lower pressure.

3D Fluid Dynamics Software Development

Dr. Anastasios Liakos, Assistant Professor, Mathematics Department, USNA
IHDIV sponsor: Dr. Mitch Gallant

A joint effort between IHDIV, the Center for Energetic Concepts Development, and the U.S. Naval Academy is underway to develop a state-of-the-art, fully three-dimensional fluid dynamics simulation software. This software will be used to test or refine models for the equation that determines fluid properties, as well as visualize flow through any type of screw configuration. The effort is motivated by the fact that most commercial codes are very rigid in their usage and do not allow the user access to the source code, therefore not allowing changes. With an in-house code, the user has the ability to fine-tune the software without incurring any licensing fees.

At its current state, the code solves the 3-D Stokes Problem. The flow domain is meshed in a CAD program (I-DEAS v.10). The data file produced is the input to the code. The output can be viewed in TECPLOT, a popular flow visualization package. Some of the code features are dynamic memory allocation, choice of polynomial approximation, and quadrature schemes. Currently, the Hershel-Bulkley constitutive equation is being incorporated into the code. Future developments include insertion of time and temperature effects.

The Gemini Project: Improved Boundary Conditions for Arbitrary Bodies on Cartesian Meshes

Thomas J. Mahar, Associate Professor, Mathematics Department, USNA
IHDIV sponsor: Dr. Andrew Wardlaw, Jr.

The goal of the Gemini project is to construct accurate models of underwater explosions and to use the results of simulations with these models to improve the design of torpedo warheads. During 2004, Professor Mahar continued investigations begun during the summer of 2003 in cooperation with the Gemini Project.

As a starting point for investigating improved boundary conditions for arbitrary bodies on Cartesian meshes, the publicly available CLAWPACK code, which is also a Cartesian mesh code, was obtained from LeVeque. Under the circumstances of the study, the body boundary is not coincident with grid lines, and computational cells are partly in the body and partly in the flow. New approaches were coded in this package.

Getting Onboard

Indian Head staff interested in sponsoring a USNA faculty member during the summer, please contact Dr. Suhithi Peiris, Research Liaison (suhithi.peiris@navy.mil; 301-744-4252).

USNA faculty members who wish to explore summer research opportunities at Indian Head should contact Ms. Debra T. Hughes in USNA's Office of Research and Scholarship (dhughes@usna.edu; 410-293-2518).

Future Naval Officers Make Mark as 2004 and 2005 Trident Scholars

The United States Naval Academy instituted the Trident Scholar Program in 1963 to provide an opportunity for a limited number of exceptionally capable students to engage in independent study and research during their senior year. Under this program, midshipmen in the top 10 percent of their class at the end of the first semester of their junior year are invited to submit proposed research projects and programs of study for evaluation.

The Trident Scholar Program provides an opportunity, according to the Naval Academy, for academically gifted midshipmen to "contribute their thoughts, intuition, creativity, and enthusiasm into a subtantial, non-textbook problem" during their senior year at the Academy. Scientists and engineers at Indian Head are encouraged to suggest Trident research topics of practical interest to the Navy and Marine Corps, to serve as mentors to individual Trident scholars, and to open their laboratory facilities for various phases of the students' research.

2004 Trident Scholars

MIDN 1/C DREW R. BARKER
Major: Physics
Advisors: Dr. Richard P. Fahey, Visiting Professor, Aerospace Engineering Department; Professor Larry L. Tankersley, Physics Department
Project: Sensitivity Analysis of a Space-borne Gravitational Wave Detector

MIDN 1/C MATTHEW A. BEASLEY
Major: Electrical Engineering
Advisor: Assistant Professor Samara L. Firebaugh, Electrical Engineering Department
Project: Packaging for Satellite-based Microelectromechanical Systems

MIDN 1/C DANIEL L. BOWERS
Major: Chemistry
Advisor: Assistant Professor Tammy L. Domanski, Chemistry Department
Project: ClpB Heat Shock Protein: Studies of Its Function and Regulation Under Stress Conditions

MIDN 1/C ADAM S. FISHER
Major: Electrical Engineering
Advisors: Associate Professor R. Brian Jenkins, Electrical Engineering Department; Captain Robert J. Voigt, USN, Electrical Engineering Department
Project: A Bidirectional Wavelength Multiplexed Fiber Ring Network

MIDN 1/C KATHERINE E. FOLZ
Major: Chemistry
Advisor: Associate Professor Craig M. Whitaker, Chemistry Department
Project: Synthesis and Characterization of Novel Organic Photovoltaic Devices

MIDN 1/C JAMES J. LIGHT
Major: Economics (Honors)
Advisors: Assistant Professor Pamela M. Schmitt, Economics Department; Associate Professor Suzanne K. McCoskey, Economics Department
Project: An Empirical Investigation of Product Differentiation in the Retail Gas Industry

MIDN 1/C JOSHUA M. MUELLER
Major: Physics
Advisor: Associate Professor Charles A. Edmondson, Physics Department
Project: Complex Impedance Studies of Electrospray Deposited Proton Conductors

MIDN 1/C JARED R. PATTON
Major: Naval Architecture
Advisor: Assistant Professor Paul H. Miller, Naval Architecture and Ocean Engineering Department
Project: Determining Dynamic Lift Coefficients for High Aspect Ratio Control Surfaces

MIDN 1/C JEFFREY C. PAYNE
Major: Physics
Advisor: Assistant Professor James J. Butler, Physics Department
Project: Optical Limiting in Single-mode Waveguide Systems

MIDN 1/C THOMAS A. SHAPIRO
Major: Ocean Engineering
Advisors: Assistant Professor Michael P. Schultz, Naval Architecture and Ocean Engineering Department; Associate Professor Karen A. Flack, Mechanical Engineering Department
Project: The Effect of Surface Roughness on Hydrodynamic Drag and Turbulence

MIDN 1/C YONG C. TAN
Major: Systems Engineering
Advisor: Associate Professor Bradley E. Bishop, Weapons and Systems Engineering Department
Project: An Investigation of Swarming Robots for Underwater Mine Countermeasures

2005 Trident Scholars

MIDN 1/C DANICA L. ADAMS
Major: Systems Engineering
Advisor: Associate Professor Richard T. O'Brien, Jr., Weapons and Systems Engineering Department; Associate Professor Kiriakos Kiriakidis, Weapons and Systems Engineering Department
Project: Direction of Arrival Estimation Using a Reconfigurable Array

MIDN 1/C ANDREW C. BASHELOR
Major: Mathematics (Honors)
Advisors: Assistant Professor Amy E. Ksir, Mathematics Department; Associate Professor William N. Traves, Mathematics Department
Project: Excess Intersection in Enumerative Algebraic Geometry

MIDN 1/C BRADFORD L. BONNEY
Major: Electrical Engineering
Advisors: Professor Delores M. Etter, Electrical Engineering Department; Assistant Professor Robert W. Ives, Electrical Engineering Department
Project: Non-orthogonal Iris Localization

MIDN 1/C NATHAN F. BRASHER
Major: Mathematics (Honors)
Advisors: Professor Reza Malek-Madani, Mathematics Department; Associate Professor Gary O. Fowler, Mathematics Department
Project: Computing the Hyperbolic Trajectories and their Invariant Manifolds of Flows in the Chesapeake Bay

MIDN 1/C SARAH M. COULTHARD
Major: Mechanical Engineering
Advisors: Associate Professor Ralph J. Volino, Mechanical Engineering Department; Professor Karen A. Flack, Mechanical Engineering Department
Project: Effects of Pulsing on Film Cooling of Gas Turbine Airfoils

MIDN 1/C MICHAEL G. DODSON
Major: Aerospace Engineering
Advisor: Assistant Professor David S. Miklosovic, Aerospace Engineering Department
Project: An Historical and Applied Aerodynamic Study of the Wright Brothers' Wind Tunnel Test Program and Application to Successful Manned Flight

MIDN 1/C THOMAS W. DUNBAR
Major: Systems Engineering
Advisor: Assistant Professor Joel M. Esposito, Weapons and Systems Engineering Department
Project: Artificial Potential Field Controllers for Robust Communications in a Network of Swarm Robots

MIDN 1/C GRANT I. GILLARY
Major: Physics
Advisors: Professor Reza Malek-Madani, Mathematics Department; Assistant Professor Kevin L. McIlhany, Physics Department
Project: Normal Mode Analysis of Complex Geometries

MIDN 1/C SEAN A. JONES
Major: Computer Science
Advisor: Associate Professor Donald M. Needham, Computer Science Department
Project: Comparison of Metrics for Software Safety Prediction in Embedded Systems

MIDN 1/C ELIZABETH R. KEALEY
Major: Mechanical Engineering
Advisors: Assistant Professor Andrew N. Smith, Mechanical Engineering Department; Assistant Professor Peter J. Joyce, Mechanical Engineering Department
Project: Thermal Management of Copper Rails in an Electromagnetic Railgun

MIDN 1/C STEPHEN S. McMATH
Major: Mathematics (Honors)
Advisors: Professor W. David Joyner, Mathematics Department; Assistant Professor Frederick L. Crabbe, IV, Computer Science Department
Project: Factorization Using the Infrastructure of Binary Quadratic Form Class Groups

MIDN 1/C JOSHUA W. WORT
Major: Electrical Engineering
Advisors: Associate Professor R. Brian Jenkins, Electrical Engineering Department; Captain Robert J. Voigt, USN, Electrical Engineering Department
Project: A Network Interface Card for a Bidirectional Wavelength Division Multiplexed Fiber Optic Local Area Network

MIDN 1/C CHRISTOPHER D. WOZNIAK
Major: Naval Architecture
Advisor: Associate Professor Paul H. Miller, Naval Architecture and Ocean Engineering Department
Project: Analysis, Fabrication, and Testing of a Composite Bladed Propeller for a U.S. Naval Academy Yard Patrol (YP) Craft